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FIELD TEST OF CARBON STEEL BURNER CASINGS FOR THE LINS METHOD OF OIL RECOVERY

SANTA CRUZ, CALIFORNIA

LINS =

Ljungström In Situ Method

FIELD TEST OF CARBON STEEL CASINGS FOR THE LINS METHOD OF OIL RECOVERY

by

R. E. Helander

Santa Cruz Thermal Recovery Experiment
Santa Cruz, California

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SUMMARY

A seven-well test was run using carbon steel as a burner casing material with fluidized sand burners. This test operated for 14 months with two casing failures and several burner failures. In spite of these failures, it was concluded that carbon steel may be a satisfactory casing material, although it may be advisable to use alloy steels in that portion of the casing which is likely to become overheated.

OBJECTIVES OF THE TEST

As has been reported previously,[1] most of the earlier LINS process tests, undertaken by Svenska Skifferaljе AB. and Husky Oil Co. at Santa Cruz, were concerned with burner development. The first 100-well test, L8, was plagued with burner failures and at this time the so-called sand burner was developed. This test was then continued as test L8A to test various materials for burner casings. The results showed that the casing requirements were much less severe with sand burners. Therefore this seven-well test, called test L73, was started with sand burners to test the use of carbon steel as a burner casing material. This test, performed by Svenska, Husky, and Union Oil Co. of California, was started a few months before the second 100-well test,[2] L9, and ran concurrently with it.

DESCRIPTION OF TEST FACILITIES

Seven wells were drilled to a depth of 52 feet as shown on Figure 1. The burner wells, B1 through B7, were arranged in a hexagonal pattern with a well in the center of the hexagon. The distance between wells was 6 feet. All of the burner wells, except B1 and B7, were completed in the same way as those in the 100-well test. The casing and burner dimensions are shown on Figures 1 and 2. Wells B1 and B7 had 2-1/2 inch burner casings, as in the other wells, however the gas casing was a 1-1/2 inch pipe set alongside the burner casing, instead of a 4-inch pipe set concentrically. In addition, these wells contained 49 feet of 1-inch pipe to serve as temperature wells. The annuli of wells B5 and B6 were filled with gravel while the other five wells were left open.

The burners were also the same as those used in the 100-well test and are shown on Figure 2. The sand used was 12 to 14 mesh Monterey sand when the test was started, however this was later changed to 8 to 12 mesh sand.

In addition to the burner wells, five more temperature wells were drilled in the locations shown on Figure 1. These wells contained 52 feet of 2-inch pipe. The temperatures were measured by thermometers, which were placed in temperature bombs made of 1-inch pipe. The heat capacity of the bombs was high enough that they could be pulled to the surface on a cable and read without any measurable change in temperature taking place.

The propane-air mixture was supplied at 30 psig by the fuel system for the 100-well test. During the period before the 100-well test was started, the propane and air were mixed and controlled manually.

The production was disposed of by adding it to the production from the 100-well test. There were no metering facilities, however occasionally a production test was made by collecting the produced fluids in a small condenser-sampler. These data are shown on Table 3.

TEST OPERATION

This test was operated for 14 months at heat inputs ranging from 23,500 to 30,000 BTU/burner-hour. The test operation was influenced to a large extent by the 100-well test inasmuch as the fuel gas was supplied by the 100-well test fuel supply. The heat input was usually regulated in the 100-well test by changing the pressure in the fuel lines, and as a result the heat input in this test changed along with the 100-well test. Figure 3 shows the weekly average heat inputs during the test. From the beginning of the test on November 13, 1957, until March 24, 1958, the heat input remained constant at 30,000 BTU/burner-hour. From November 13 until December 30, the fuel was supplied by the fuel system for test L8A, which was in progress at that time. From December 30, 1957, until February 14 the heat input was controlled manually. Subsequently the fuel lines were connected to the 100-well test fuel supply and therefore the variations in heat input during the remainder of the test resulted from the variations in the 100-well test. These variations are discussed in the report on the 100-well test.[2].

Sand losses were usually higher than those in the 100-well test. These losses are also shown on Figure 3. The losses appeared to be caused mainly by the lack of disengaging space for sand slugs to break up between the sand bed and the top of the casing. In addition, this test was located at the lowest point of the fuel lines and there may have been a large amount of water entering the burners, in spite of the water traps in the lines. The rapid formation of steam from slugs of water caused momentarily high flow rates and subsequent losses of sand.

Temperature data were taken in the temperature wells at least twice each week. These data are shown on Figures 4 through 15.

Table 1 lists the time and reasons that the burners were off. The test was shut down for a total of 226 hours because of power failures and interruptions in the fuel gas supply. In addition the burners were shut off and inspected on February 27, at 2550 hours, and again on September 15, 1958, at 7351 hours. During these inspections usually several centralizers had to be replaced, as well as weak welds and eroded fittings. The remaining down-time, because of burner and casing failures, is discussed in the following section of this report.

RESULTS

Table 2 summarizes all the failures of burners and casings. Four of the wells, B1, B2, B4, and B7, were still in operation at the end of the test. The failures of the three remaining casings are discussed below.

The casing in well B3 failed on May 27, 1958, after 4685 hours of operation. At the time this casing failed there was no apparent damage to the burner except that all of the centralizers above the cone had been worn off. Three days earlier, high sand losses had caused the sand level to drop too low and the cone become overheated. The outer surface of the cone became coated with a glass-like layer of fused sand about 1/4-inch in thickness. When the casing later failed, it was felt that the casing had been weakened at this point by the high temperature. At the conclusion of the test, this casing was pulled and it was found that a small hole had been worn through the casing at a point 10 feet above the bottom. This was at the level of one of the burner centralizers and apparently the turbulence caused by this centralizer resulted in the sand cutting a hole in the casing.

The casing in well B5 failed at 4492 hours after the start of the test, on May 19, 1958. The burner did not appear to be damaged at this time and there was no explanation for this failure.

The supply tube on the burner in well B6 burned off 6 inches above the cone on February 26, 1958, after 2540 hours. The flame at this point was impinging directly on the casing and burned a hole in it. This was probably caused by a restriction in the fuel gas flow rate which allowed the flame to travel up into the supply tube. This in turn overheated the supply tube and caused its failure.

At the conclusion of the test an attempt was made to pull the casing in well B1. The casing was pulled in two at a depth of 24 feet, four feet above the location of the cone. This burner had been overheated on November 26, 1958, when the flame had moved up into the supply tube. The temperature in well T1 at this point reached 1400°F. Apparently the casing became weakened at this time but it did not fail. A specimen was taken from the lower end of the recovered portion of the casing. The analysis of this specimen[3] showed less than 1/10-inch of parent metal with deposits of sulfide scale on the outside of the pipe and oxide on the inside. There was evidence of grain growth and solution of pearlite, which appeared in the spheroidized state, which means that the temperature was in the range of 1300°F. or higher.

The wall thickness was measured on several casings, after grinding off all the scale. In no case was the wall thickness less than that listed in the specifications for schedule 40 pipe, which is 0.203 ± 0.025 inches.

Two of the above failures, in B3 and B5, can be considered as casing failures rather than burner failures. Thus, out of seven wells, there were two casing failures and one casing which was destroyed by a burner failure. The high mortality rate for the burners was due in part to the fact that the burners were quite shallow and there was insufficient disengaging space above the sand bed. If burners are used in deeper intervals with longer sand beds, they will not be so sensitive to small losses of sand.

It appears that the use of carbon steel casings depends upon the stability of the burners, i.e., with normal burner operation at temperatures below 1300°F., carbon steel may be satisfactory, however, there is very little safety factor to allow for difficulties in burner operation.

Inasmuch as the test pattern was quite small with high losses to the surroundings, and the concurrent 100-well test was yielding data on production, few production data were taken during this test. These data were intended mainly to aid in preventing tar production in the 100-well test, i.e., the seven-well test served as a pilot unit to test the methods to be used in the 100-well test. These data are shown on Table 3. There was frequent plugging of the production lines by tar and the most effective methods for its removal were the application of heat and flushing of the lines with crude oil. Crude oil and various amounts of Dow Corning Antifoam-A were injected into the production casings when the test was started, and on several occasions during the test, however this was of no apparent benefit in preventing tar production. Also the gravel packing around wells B5 and B6 didn't appear to have any effect.

CONCLUSIONS

1. Carbon steel is a satisfactory material for burner casings as long as there is no overheating of the burners. It may be advisable to use a short section of alloy steel, e.g., the 5% chromium, 1-1/2% silicon, 1/2% molybdenum alloy used in the 100-well test, in the portion of the casing which is likely to be overheated.

2. The burners should be improved so that they have more stable and trouble-free operation. This may be partially remedied when longer and deeper burners are used.

3. Injection of oil and antifoaming agents into the formation has little or no effect on the production of tar.

4. Although sulfide and oxide scales are formed, there is no significant loss of metal except when the casing is overheated.

5. Packing the annulus with gravel did not have any significant effect on production or heat transfer.

6. The most satisfactory method of dealing with produced tar was to heat the production lines and flush them with crude oil.

This test was conducted by W. J. Shirley, B. Persson, M. O. Eurenius, J. H. Duir, and the author.

Robert E. Helander

Robert E. Helander

REFERENCES

1. B. Persson, "Oil Recovery from Tar Sand with the LINS Method - Report on Field Tests at Santa Cruz, California, 1955-1957", Santa Cruz Thermal Recovery Experiment, September 12, 1958 (3 volumes).

2. R. E. Helander and B. Persson, "Field Test of the LINS Method for Recovery of Oil from Tar Sand", Santa Cruz Thermal Recovery Experiment, June 30, 1959 (2 volumes).

3. L. M. Dvoracek, "Tar Sands Project" (report on the metallurgical analysis of a burner casing), Union Oil Co., Research Dept. Memo No. JEH-902M, March 25, 1959. (Distributed in letter No. JES-60 from John E. Sherborne to Santa Cruz project participants, April 22, 1959.)

TIME BURNERS
WERE OFF IN TEST L73.

Date	Hours from start	Burners off Hours	No.	Remarks
1957				
11.20	181	9	B1 to 7	Propane supply failed.
12.1	438	3	B1	Burner stuck when a thermometer holder fell down in the casing. Cone placed at 26.5 feet.
12.21	456	25	B1	Thermometer Holder fished up. Cone placed at 28 feet.
12.9	625	3	B1 to 7	Explosion in L8A F-line.
12.11	674	1	B1 to 7	Propane supply failed.
12.12	696	2	B1 to 7	Power failure.
12.13	724	2	B1 to 7	Explosion in L8A F-line.
12.30	1131	24	B1 to 7	A separate hand regulated mixing station built because L8A was shut off.
1958				
1.1	1188	15	B1 to 7	Propane vaporizer failed.
1.2	1210	14	B1 to 7	New propane regulator installed.
1.9	1378	7	B1 to 7	Power failure.
1.11	1430	9	B1 to 7	Propane regulator failed.
1.14	1486	2	B1 to 7	Oilfilter in propane line installed built of two 2'8" long 6" pipes filled with burlap and coupled parallel.
1.17	1568	2	B1 to 7	Propane vaporizer failed.
1.31	1894	1	B1 to 7	Propane vaporizer adjusted.
2.11	2160	1	B1 to 7	Burners inspected.
2.14	2334	2	B1 to 7	Installing L9 propane line.
2.20	2379	4	B1 to 7	By-pass for propane vaporizer installed.
2.26	2540	7658	B6	Burner casing and 1/4" supply tube 6" above cone burned off.
2.27	2550	2	B1 to 5,7	Burners inspected.

Date	Hours from start	Hours	No.	Remarks
3.2	2616	2	B1 to 5,7	L9 vaporizer failed.
3.3	2638	4	"	L9 F-gas proportioner failed.
	2645	28	"	-"-
3.6	2716	3	"	Power failure.
3.7	2736	4	"	L9 F-gas proportioner failed.
3.17	2975	7	"	L9 F-gas proportioner adjusted.
3.18	2997	9	"	Maintenance work on L9 propane line.
3.25	3173	2	"	1 ft 4" nipples welded on top of burner casing.
3.26	3190	7	"	Water drains installed in L9 F-lines.
4.1	3335	8	"	Maintenance work on L9 F-station.
4.4	3407	5	"	Power failure.
	3412	19	B7	Orifice plate plugged.
4.15	3670	5	B1 to 5,7	Changed to separate F-line. After 2 days switched back to L9 F-line.
5.1	4064	20	B2	Cone burned off. Weak welding seam to supply tube.
5.8	4223	3	B1 to 5,7	Power failure.
5.9	4244	4	"	" "
5.14	4367	3	"	" "
5.15	4390	1	"	" "
5.19	4492	5706	B5	Burner casing burned off. Burner was OK.
5.20	4512	82	B1	Shut off because it was burning in annulus of supply tube and casing.
5.23	4586	2	B2 to 4,7	Power failure.
5.24	4609	2	B1 to 4,7	" "
	4611	49	B1,3,7	B3 cone was "glass" coated with fused sand. The sand-loss had been high.
5.27	4685	5513	B3	Burner casing burned off. All centralizers above cone were erroded off. Burner was otherwise OK. The sandloss had b en large.

	start	Hours	No.	Remarks
5.27	4685	2	B1,2,4,7	New centralizers above cone installed. The old ones were erroded off.
7.27	6140	4	"	Power failure.
8.9	6471	1209	B1	½" supply tube burned off at 15 feet. Burner fell down in sand and was stuck.
8.10	6495	7	B2,4,7	Propane vaporizer failed.
8.20	6731	67	B7	Supply tube broke off at cone.
9.6	7125	1	B2,4,7	Power failure.
9.15	7351	3	"	Replacing erroded off centralisers.
10.25	8312	13	B1	Supply tube broke off at the elbow on the surface.
10.29	8401	28	B1	Supply tube was unscrewed during sandcheck and burner fell down in the sand and was stuck.
	8409	6	B2,4,7	Power failure.
10.31	8454	94	B7	1/4"-½" bell reducer erroded off. Burner fell down in the sand and was stuck.
11.3	8520	1	B1	½" supply tube was partially plugged by rust.
11.17	8857	4	B1,2,4,7	Explosion in L9 F-lines.
11.26	9075	43	B1	Supply tube and orifice plate were partially plugged by rust. The F-gas was burning in the supply tube. Temp. in T1 at 24 feet was 1400°F.
1959				
1.12	10198			Test shut off.

SUMMARY.
=======

Burner No.	Burner off Hours	% of total test time
B1	1660	16.28
B2	246	2.41
B3	5761	56.49
B4	226	2.22
B5	5901	57.86
B6	7756	76.05
B7	455	4.46
Average per burner	3144	30.82

The test was shut down 226 hours which are included in the above figures.

Heat input in Million BTU.

B1	232.8
B2	272.9
B3	127.6
B4	273.3
B5	123.4
B6	73.3
B7	267.3
	1,370.8

Table 2

BURNER AND CASING FAILURES

Well B1

Date	Hours in Service	Time Off (hrs)	Reason
5-20-58	4512	82	Flame in annulus near supply tube. No damage.
8-9-58	6471	1209	1/2-inch supply tube burned off 15' from surface. Burner fell into sand.
10-25-58	8312	13	Supply tube broke off at surface.
10-29-58	8401	28	Supply tube unscrewed at surface.
11-3-58	8520	1	Supply tube plugged with rust.
11-26-58	9075	43	Supply tube and orifice plugged with rust. Flame in supply tube. Temperature at 24' in T1 rose to 1400°F.
		1376	

Well B2

5-1-58	4064	20	Cone burned off. Had weak weld on supply tube.

Well B3

5-24-58	4611	49	High sand loss caused overheating of cone, which became covered with fused sand. No apparent damage.
5-27-58	4685	5513	Burner casing failed. All centralizers above cone worn off. Burner undamaged. Not returned to service.
		5562	

Table 2 (continued)

Date	Hours in Service	Time Off (hrs)	Reason
	Well B4		
No burner or casing failures.			
	Well B5		
5-19-58	4492	5706	Burner casing failed. Burner undamaged. Not returned to service.
	Well B6		
2-26-58	2540	7658	1/4-inch supply tube burned off 6 inches above the cone. Casing burned off at same depth. Not returned to service.
	Well B7		
4-4-58	3412	19	Orifice plugged with rust and dirt.
8-20-58	6731	67	Supply tube broke off at cone.
10-31-58	8454	94	1/4" x 1/2" bell reducer broke off. Burner stuck in sand.
		180	

Table 3

L73 PRODUCTION AND INJECTION DATA

Date	Hours from Start	Oil Injected Gal.	Oil Injected Well No.	P-lines plugged 1/2" from Well No.	P-gas Samples Well No.	P-gas Samples Oil Bbls/d.	P-gas Samples Water Bbls/d.	Oil °API	Remarks
1957									
11-13	0	40	B1						28° API oil injected with compressed air.
		30	B2						Also 4.8 ml Antifoam A.
		30	B3						Also 1.6 ml Antifoam A.
		40	B4						
		20	B5						
		10	B6						
		30	B7						Also 9.6 ml Antifoam A.
	4								Oil and water production started from B1 to B4, B7.
11-18	120	30	B6	B6					Tar produced, oil and 2.5 ml Antifoam A were injected.
11-20	170	10	B5						B6 producing but not B5.

Date	Hours from Start	Oil Injected Gal.	Oil Injected Well No.	P-lines plugged 1/2" from Well No.	P-gas Samples Well No.	P-gas Samples Oil Bbls/d.	P-gas Samples Water Bbls/d.	Oil °API	Remarks
11-22	230				B1			approx. 17	The samples were taken at the actual P-gas pressure of 1.0 psig. Only the Water/Oil ratio was measured which was 7.3, 49, 24, 19, 99, 49 and 99, respectively.
					B2			approx. 20	
					B3			approx. 23	
					B4			27	
					B5			approx. 11	
					B6			approx. 11	
					B7			approx. 25	
11-26	310			B5 & B6					Plugged by tar.
		40	B5						Also 10 ml Antifoam A. Gravity of inj. oil was 26° API.
		20	B6						
		30	B7						
11-28	360								When P-gas pressure was decreased below 1.5 psig sampling, tar was produce
12-1	445			B1 to B7					About 1 bbl tar was produ
12-2	453								Oil circ. through main P-l and heated twice a day.
12-3	480			B7					Produced tar.
		30	B7						
12-5	530			B7					Most of the tar came from 10 gal. oil circulated thr main P-lines every hour d nights.
12-7	580								Oil circulated through P-l stopped.

Table 3 (continued)

Date	Hours from Start	Oil Injected Gal.	Oil Injected Well No.	P-lines plugged 1/2" from Well No.	P-gas Samples Well No.	P-gas Samples Oil Bbls/d.	P-gas Samples Water Bbls/d.	Oil °API	Remarks
12-8	600			B1, 2, 6, 7					Oil circulated through P. during nights restarted.
12-16	800								All gas wells still produ tar. Frequent plugging o P-lines. Oil circulatio shut off.
12-20	890			B1-7					
12-22	940			B1-7					
12-26	1030			B2, 7					
12-27	1060			B6					
12-29	1110				B1-7			14.5	
1958									
1-6	1292				B1-7	0.39	9.8	24	
1-12	1460								
1-13	1470			B5, 6					
1-19	1610			B5					
1-25	1750			B1					
1-26	1780			B1					
1-27	1810			B1					Gas casing also plugged. Unplugged by pumping oil into the well when cone was placed at 16 ft.

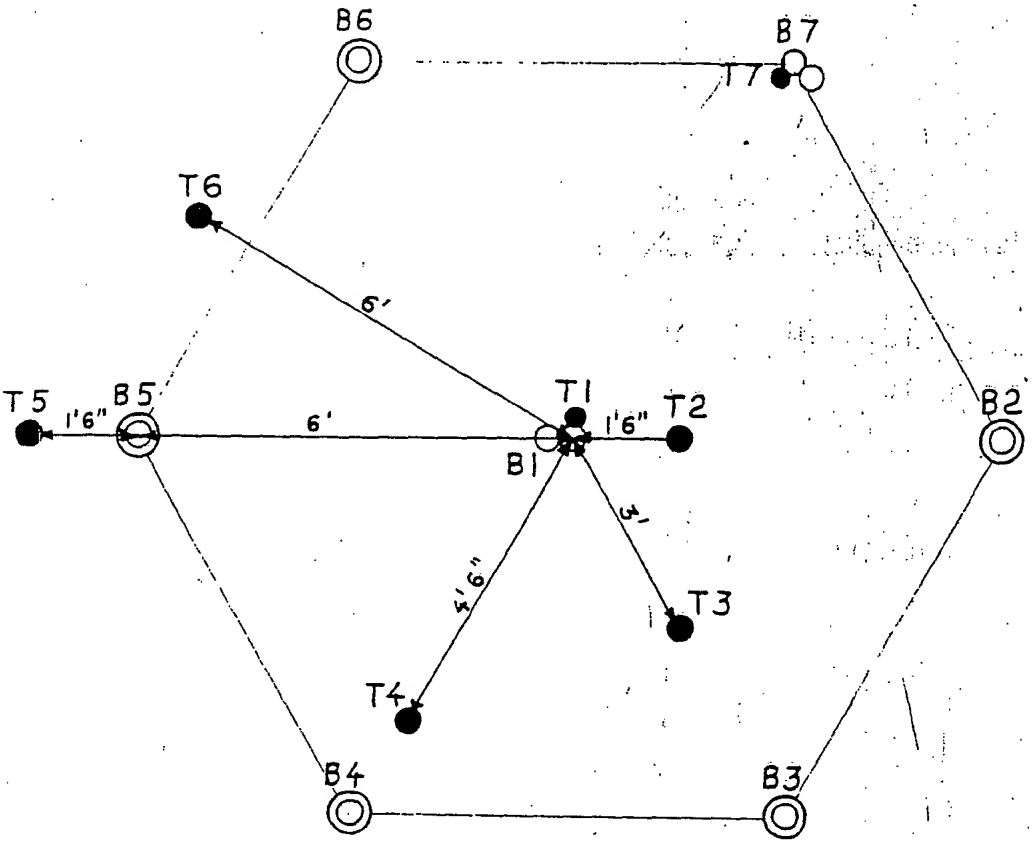
Table 3 (continued)

Date	Hours from Start	Oil Injected Gal.	Oil Injected Well No.	P-lines plugged 1/2" from Well No.	P-gas Samples Well No.	P-gas Samples Oil Bbls/d.	P-gas Samples Water Bbls/d.	Oil °API	Remarks
2-9	2110			B4, 5					Plugged by heavy emulsion
		10	B4						
		10	B5						
2-10	2140			B2					Plugged by heavy emulsion
2-15	2260	15	B4						B4 and B5 gas casings plu
		15	B5						Cone placed at 20 ft. for hours during oil injectio
2-28	2570			B1, 3, 4, 7					
3-1	2600			B1, 2, 3, 7					
3-12	2860				B4	0.10	0.26	25.6	Sample for 1 hour.
3-13	2880				B1	0.11	0.26	28.7	" " " "
3-15	2930				B5	0.04	0.27	37.3	" " " "
					B1-7	0.27	0.70	22.9	" " " "
3-21	3070			B2, 3, 6					Plugged by emulsion.
					B3	0.06	0.34	31.3	
3-22	3100			B2, 3, 6					Most tar came from B6.
3-24	3150				B1-7	0.16	1.00	26.6	
3-28	3240								

Table 3 (continued)

Date	Hours from Start	Oil Injected Gal.	Oil Injected Well No.	P-lines plugged 1/2" from Well No.	P-gas Samples Well No.	P-gas Samples Oil Bbls/d.	P-gas Samples Water Bbls/d.	Oil °API	Remarks
4-7	3480								
4-8	3510				Bl-7	0.07	0.93	36.1	
4-25	3910				Bl-7	0.06	0.76	35.6	
					Bl-7	0.37	2.00	30.0	P-gas pressure 2.7 psig. Sampled during 2 hours at 2.2 psig.
6-11	5040				Bl-7	0.00	0.04		Sampled during 1 hour at 4.2 psig P-gas pressure.
6-25	5380				Bl-7	0.00	0.04		Sampled during 1 hour at 3.1 psig P-gas pressure. No oil.

WELL PATTERN AND MATERIALS

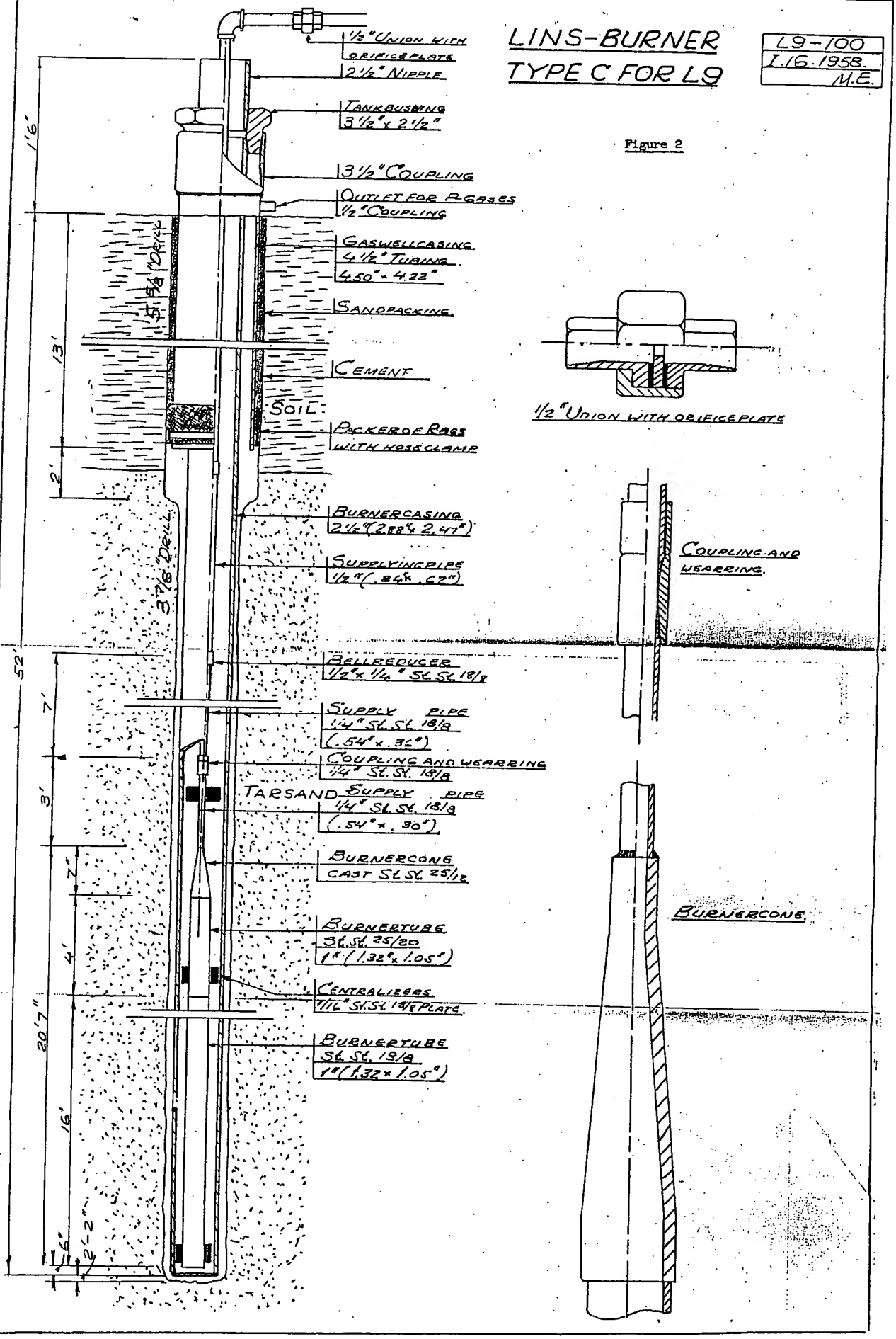


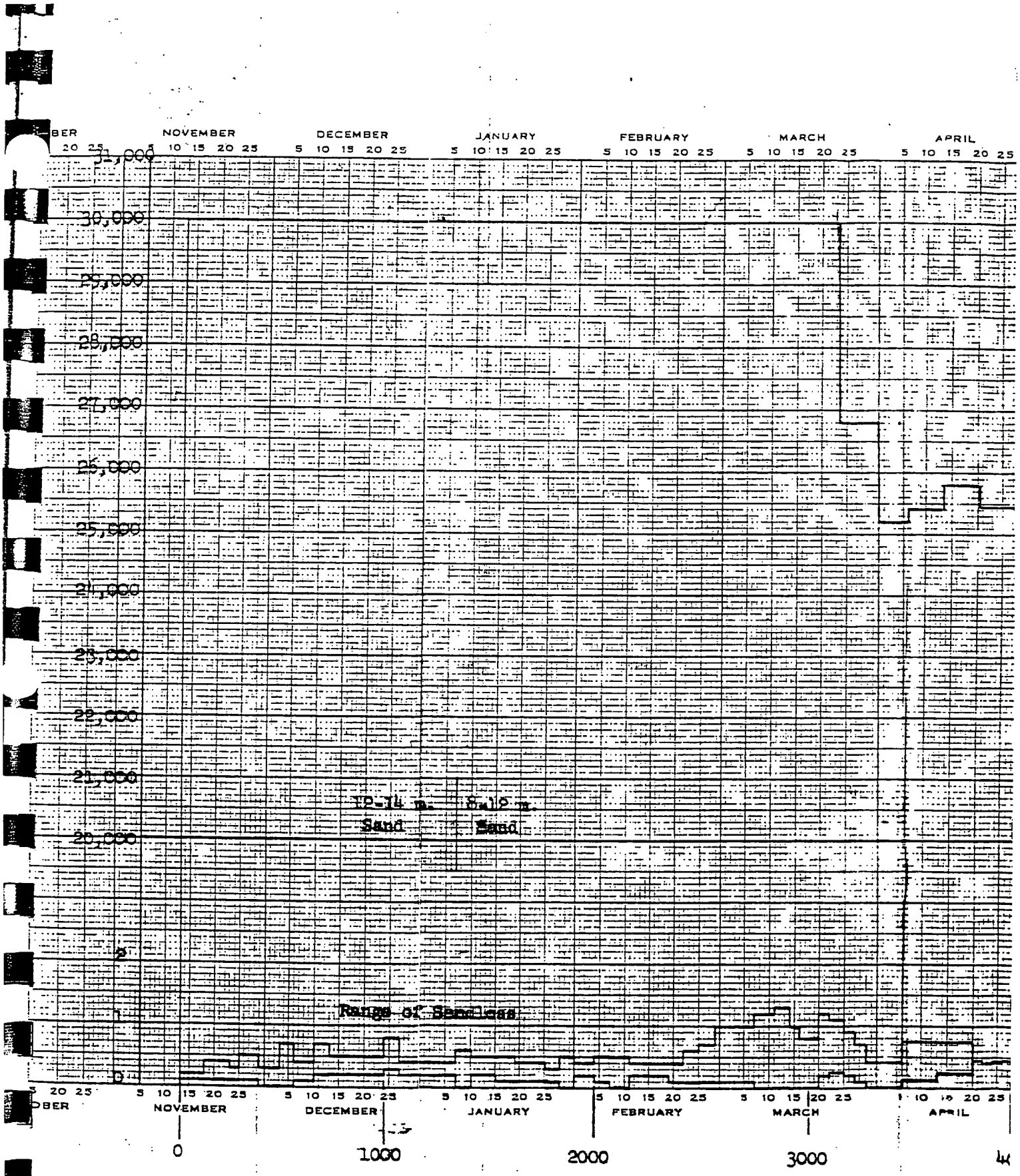
49 FT. 2½" BURNER CASING OF IRON A-106.
49 " 1" J-55 PIPE FOR THE TEMPERATUREWELLS T1 AND T7, SPOTVELDED TO THE BURNER CASINGS B1 AND B7.
52 " 2" J-55 PIPE FOR THE TEMPERATURE WELLS T2, T3, T4, T5 AND T6.
13 " 4¼" x 4" IRON TUBING FOR THE CONCENTRIC GASWELLS AROUND THE BURNER CASINGS B2, B3, B4, B5 AND B6.
13 " 1½" J-55 PIPE FOR THE SEPARATE GASWELLS ALONG THE BURNER CASINGS B1 AND B7.
20 " 1" BURNER TUBES PLACED BETWEEN 28 AND 48 FT BELOW GROUND SURFACE.
B5 AND B6 CONCENTRIC GASWELLS FILLED WITH 4-10 MESH GRAVEL UP TO 16 FT FROM GROUND SURFACE.

LINS-BURNER TYPE C FOR L9

L9-100
I.16.1958.
M.E.

Figure 2




BER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
5 10 15 20 25
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30,000
29,000
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26,000
25,000
24,000
23,000
22,000
21,000
20,000
TP-14 m. 8.10 m.
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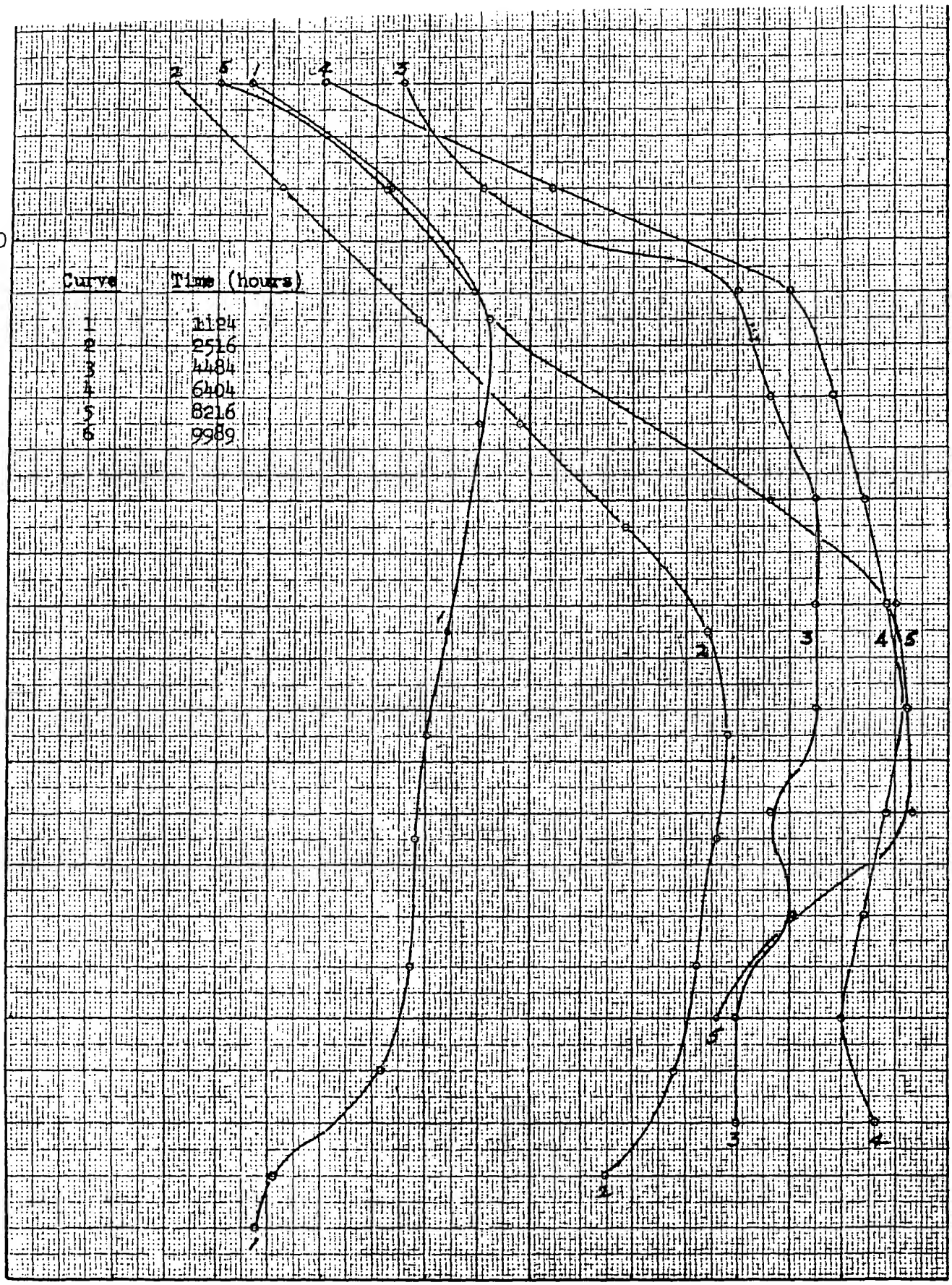
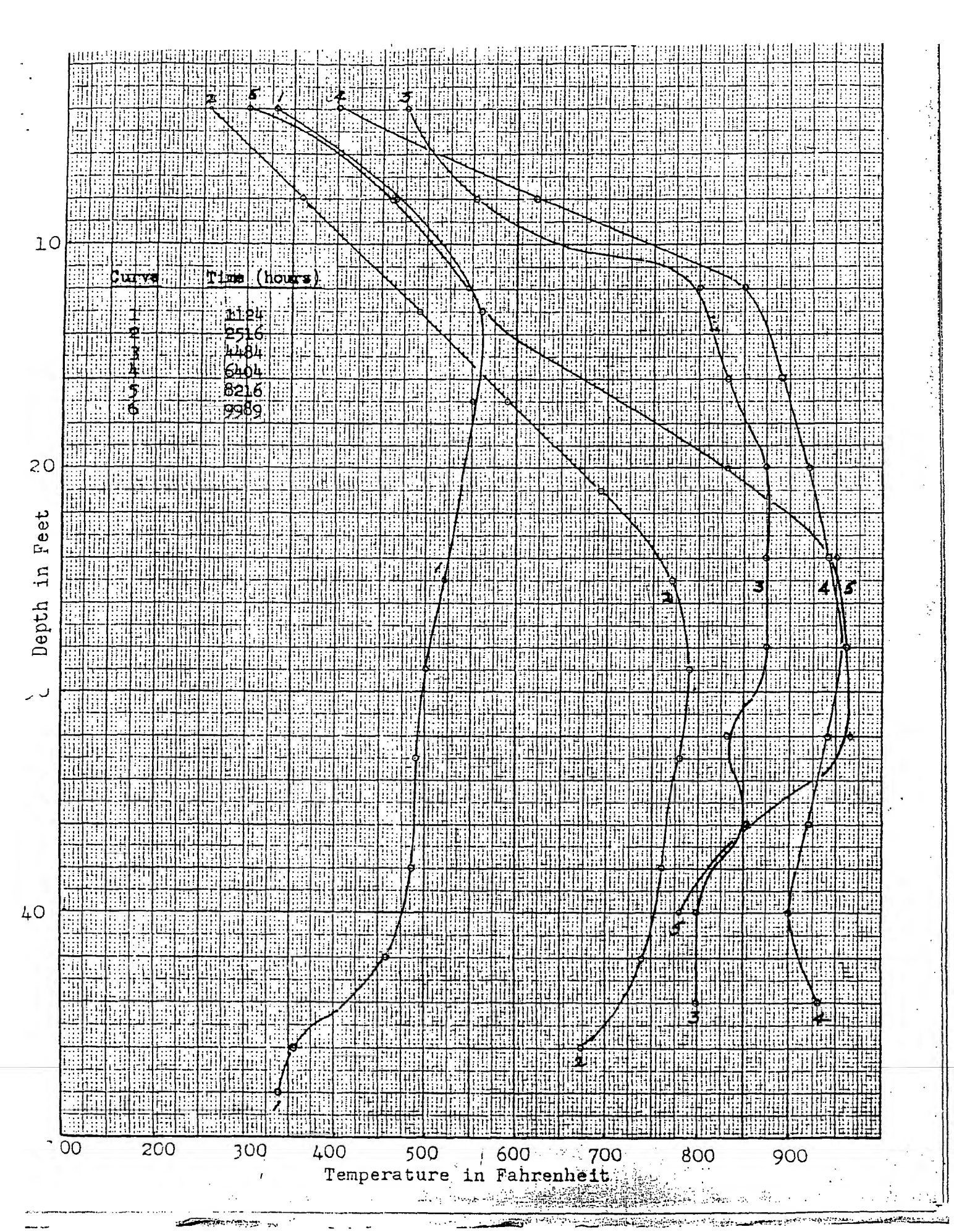
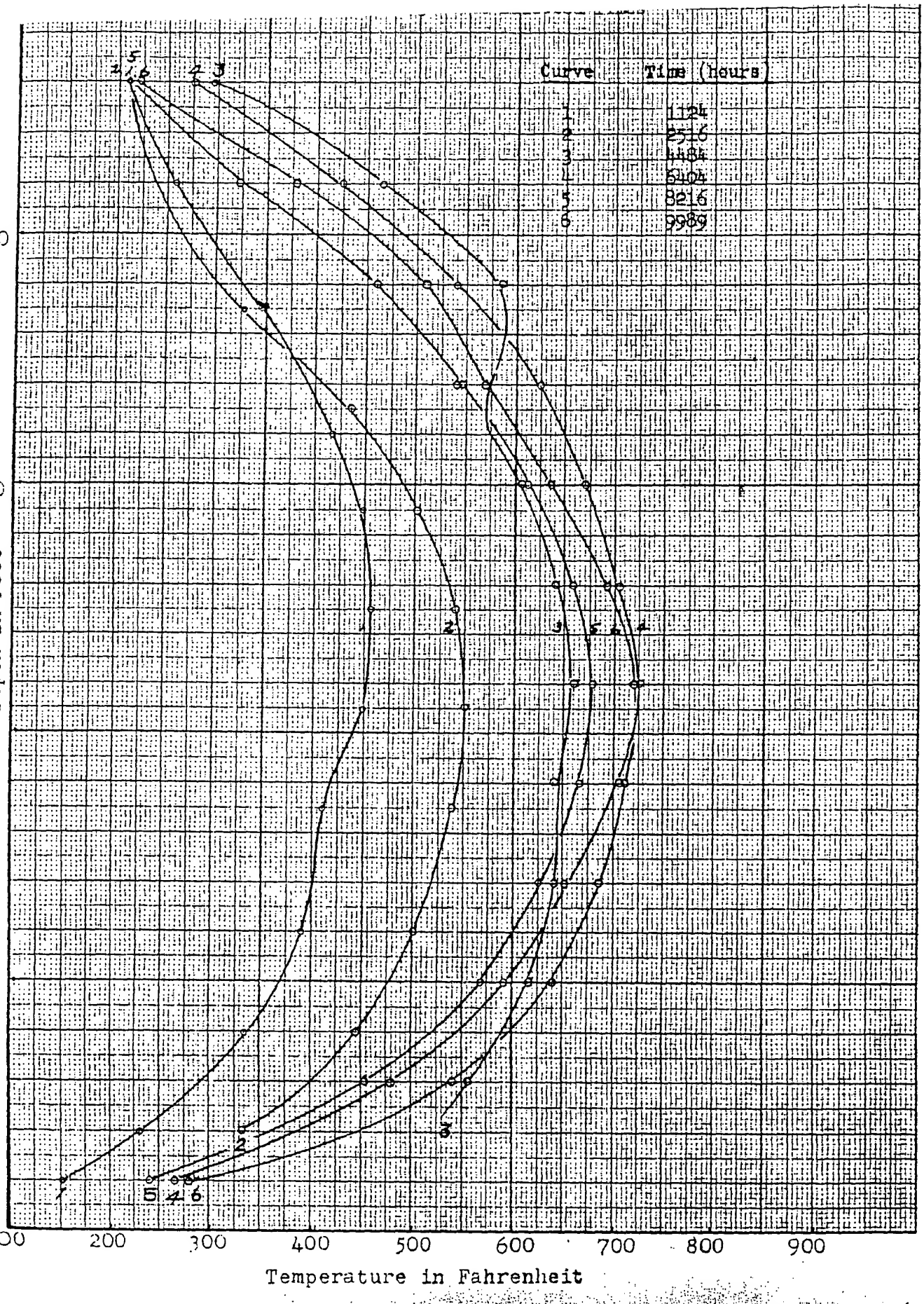
1000
2000
3000




Curve Time (hours)
1 1124
2 2516
3 4484
4 6404
5 8216
6 9989
10
20
40
Depth in Feet
00 200 300 400 500 600 700 800 900
Temperature in Fahrenheit


Curve Time (hours)
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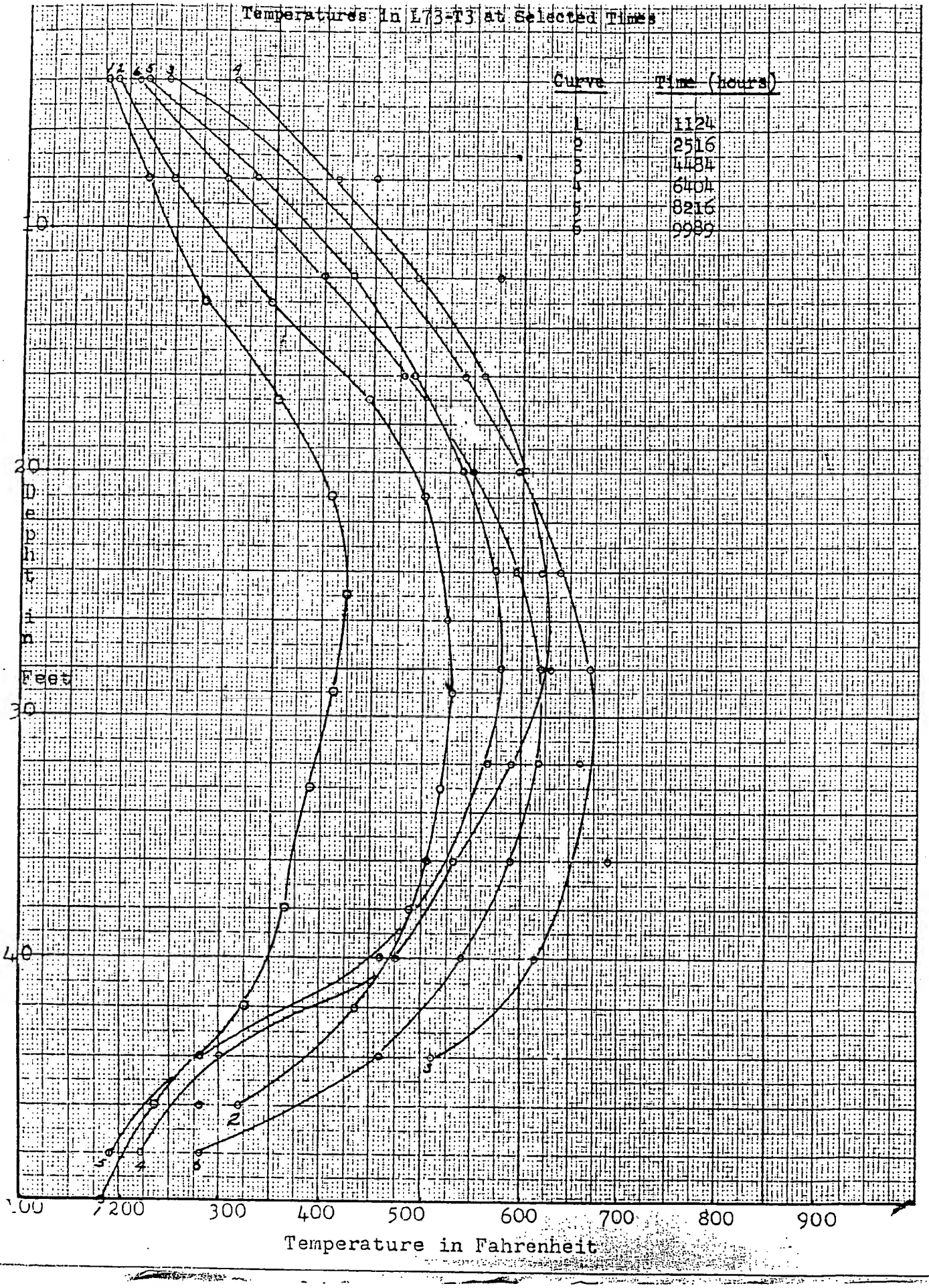
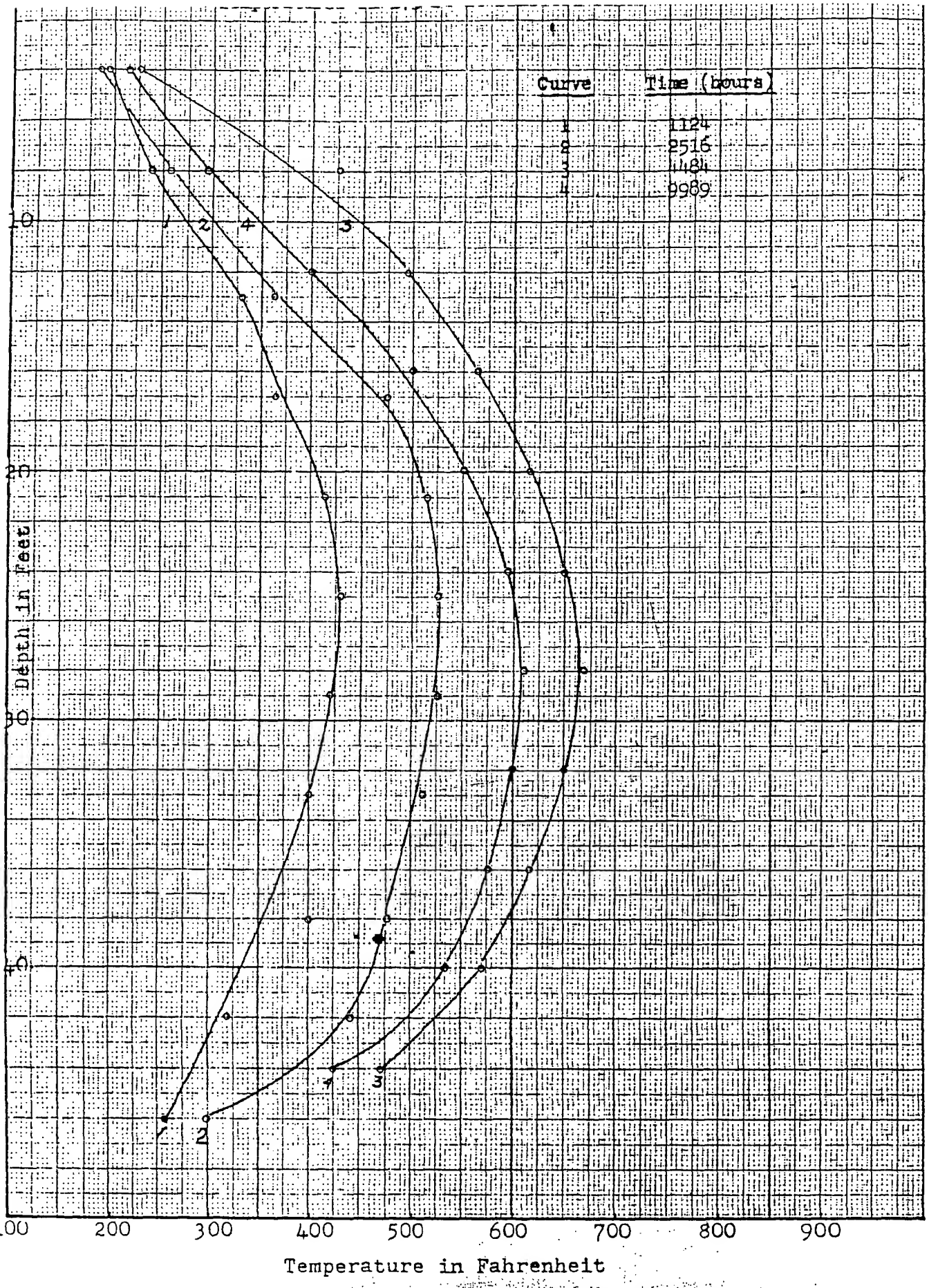
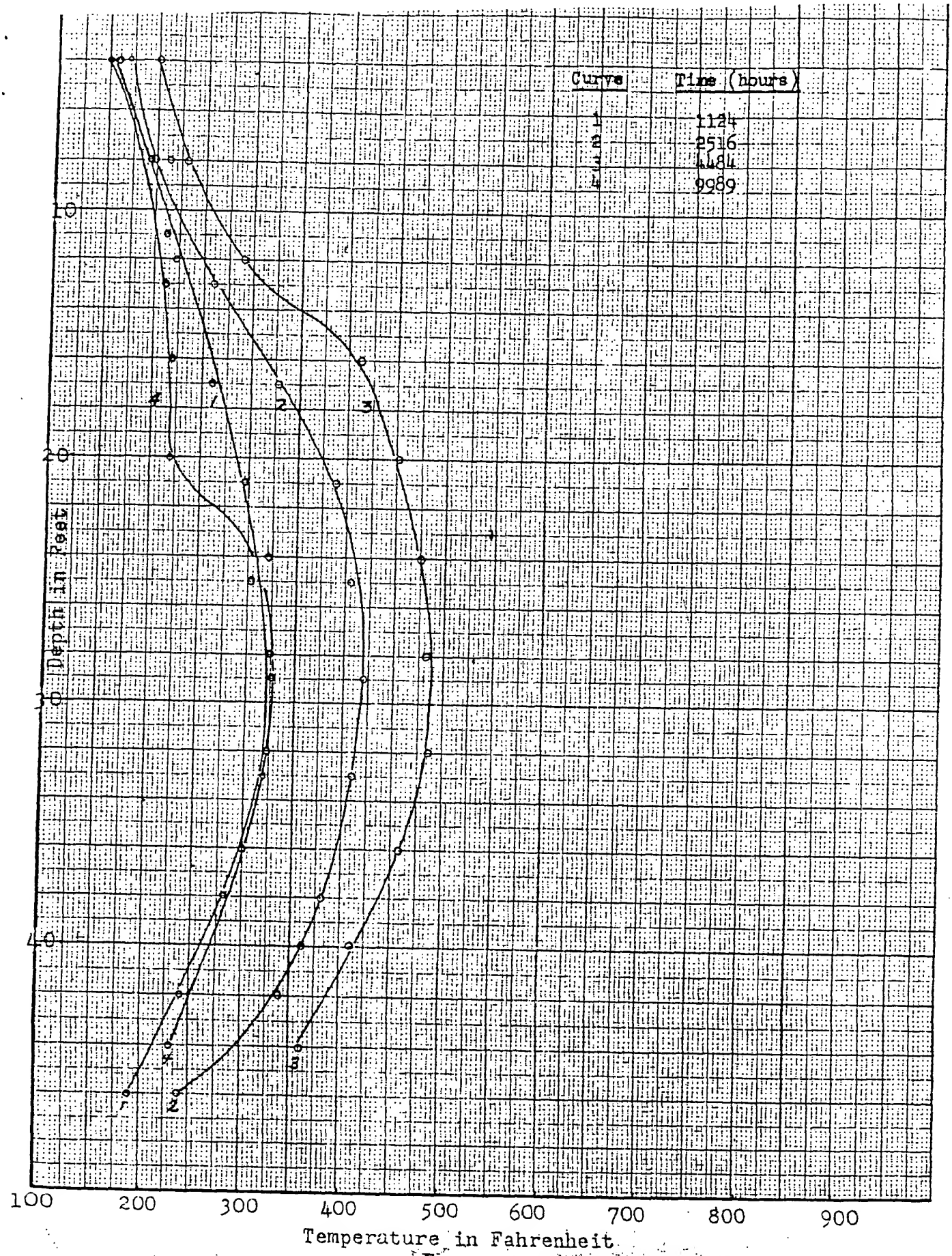
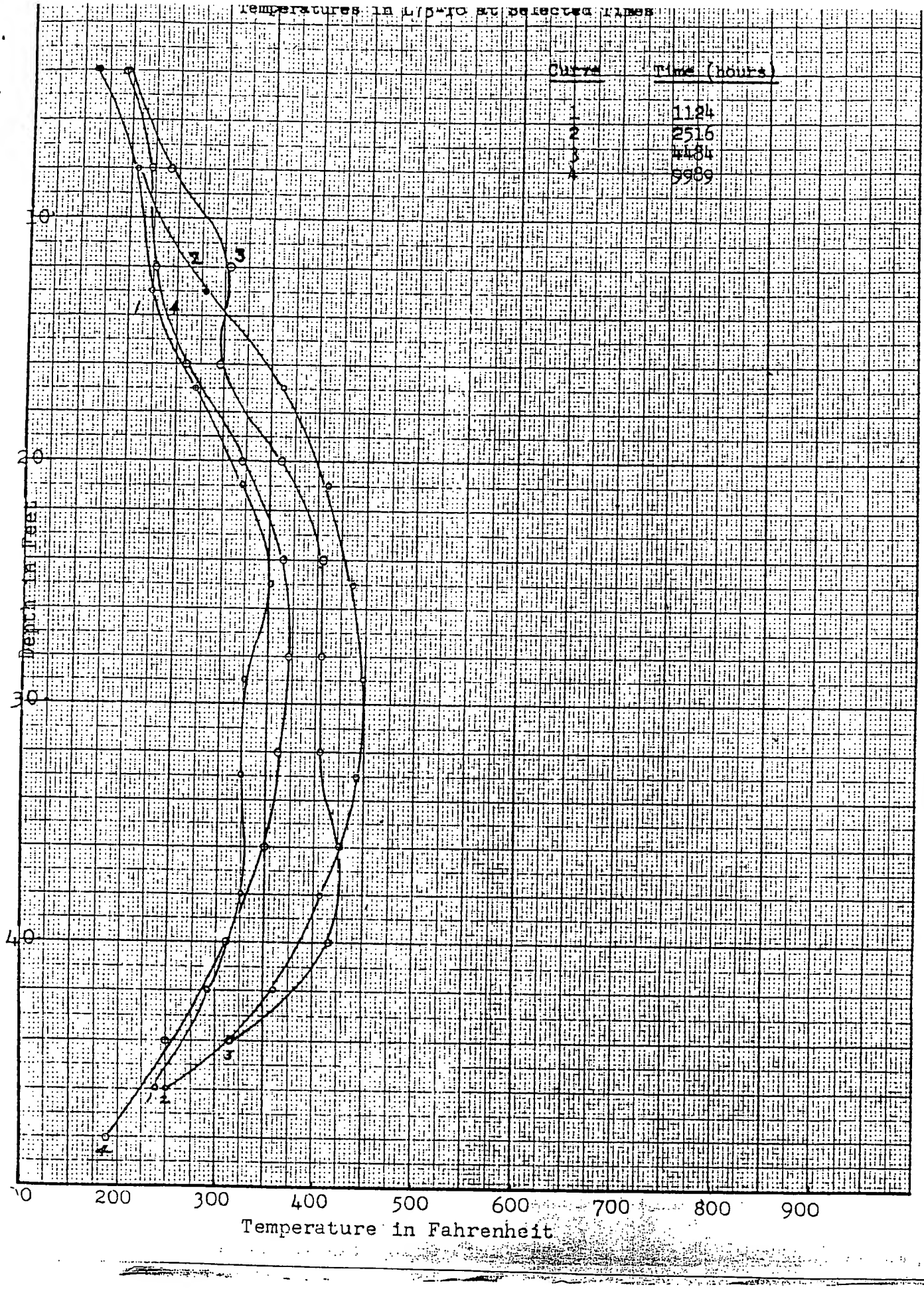
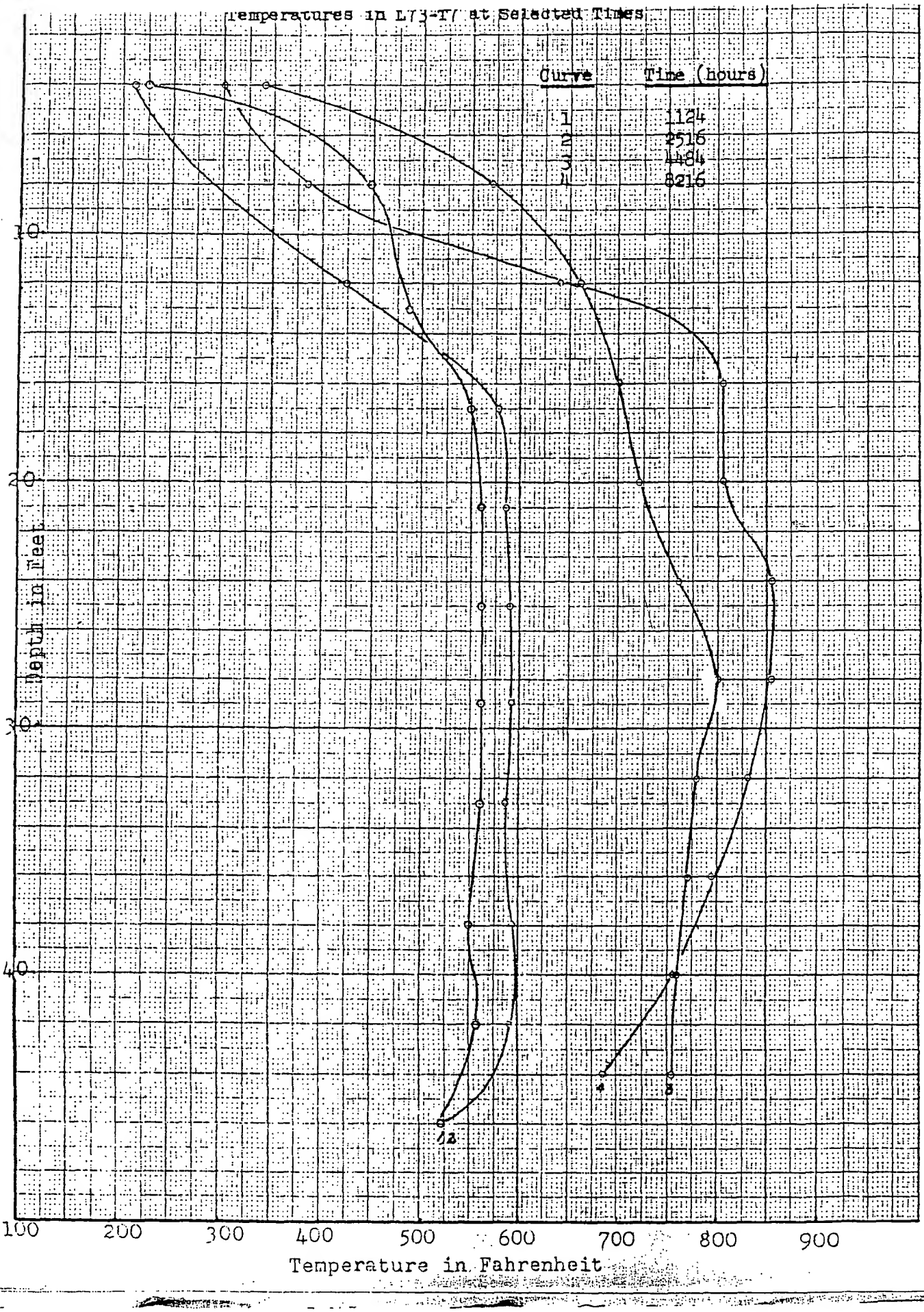
2 2516
3 4484
4 5404
5 8216
6 9989
Depth in Feet
10
20
40
100
200
300
400
500
600
700
800
900
Temperature in Fahrenheit

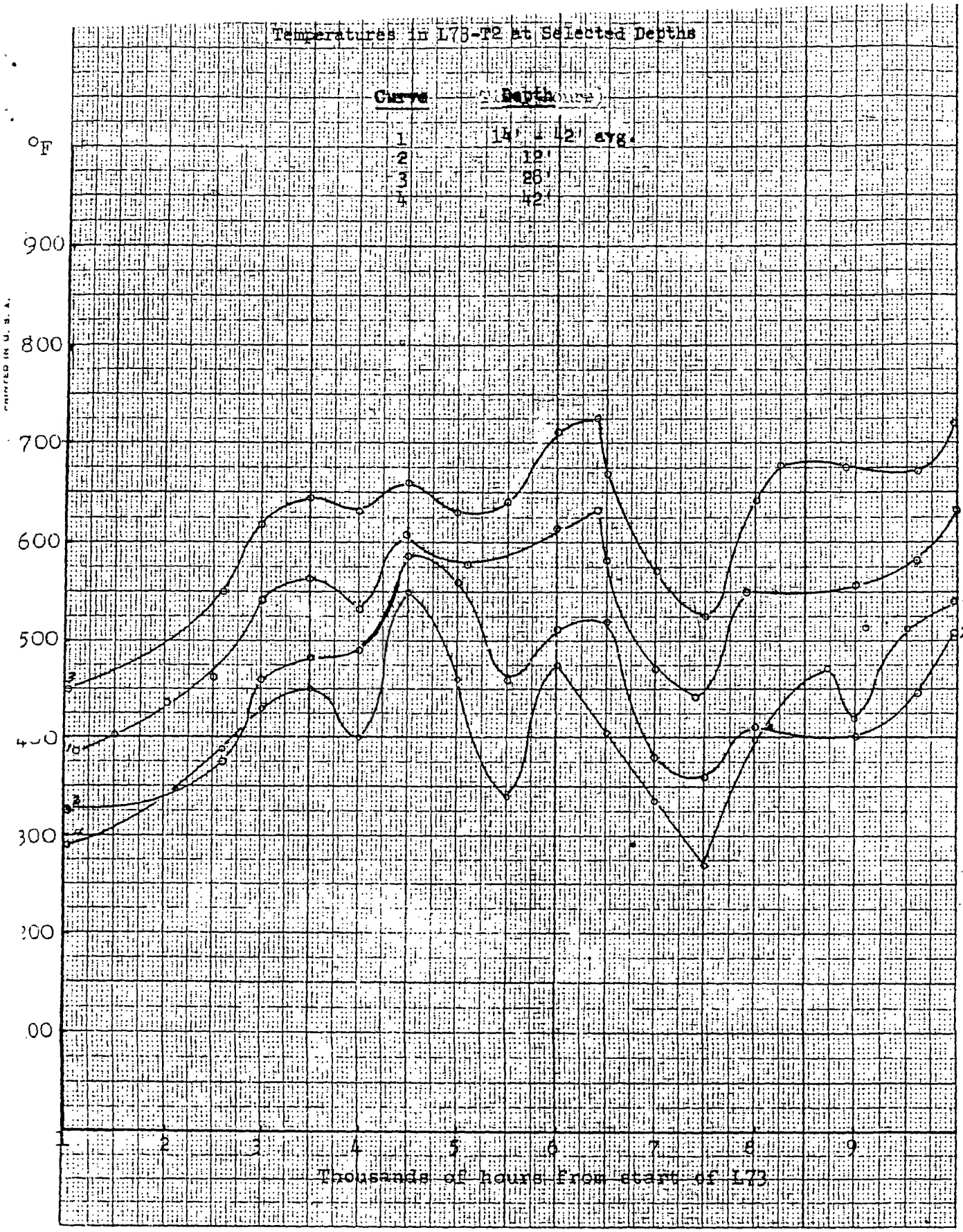

Temperatures in L73-T3 at Selected Times
Curve
Time (hours)
1
1124
2
2516
3
4484
4
6404
5
8216
6
9989
Depth in Feet
10
20
30
40
100
200
300
400
500
600
700
800
900
Temperature in Fahrenheit

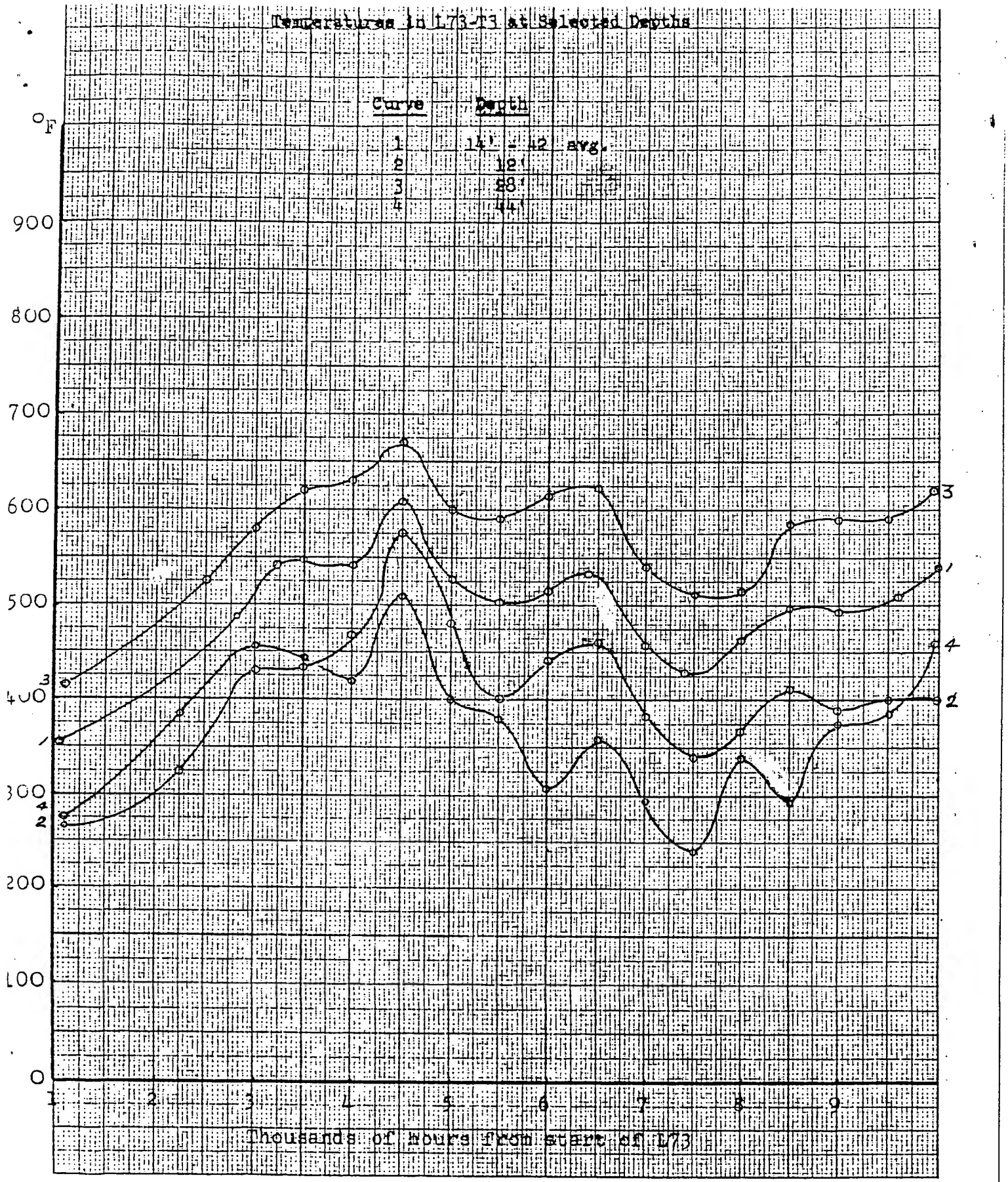

Curve
Time (hours)
1 1124
2 2516
3 4484
4 9989
10
20
30
40
Depth in Feet
100
200
300
400
500
600
700
800
900
Temperature in Fahrenheit

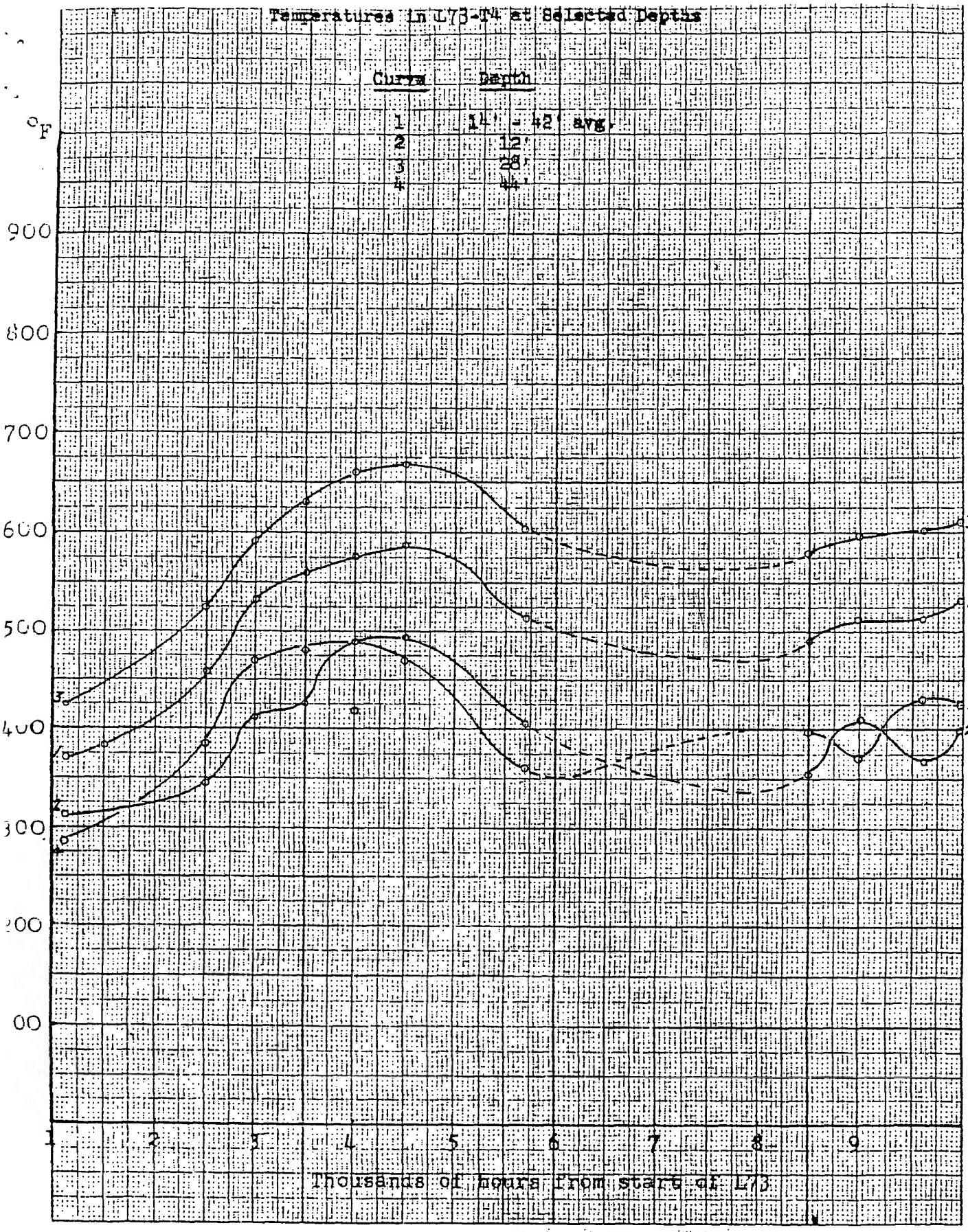

Curve
Time (hours)
1
1124
2
2516
3
4484
4
9989
Depth in feet
10
20
30
40
100
200
300
400
500
600
700
800
900
Temperature in Fahrenheit

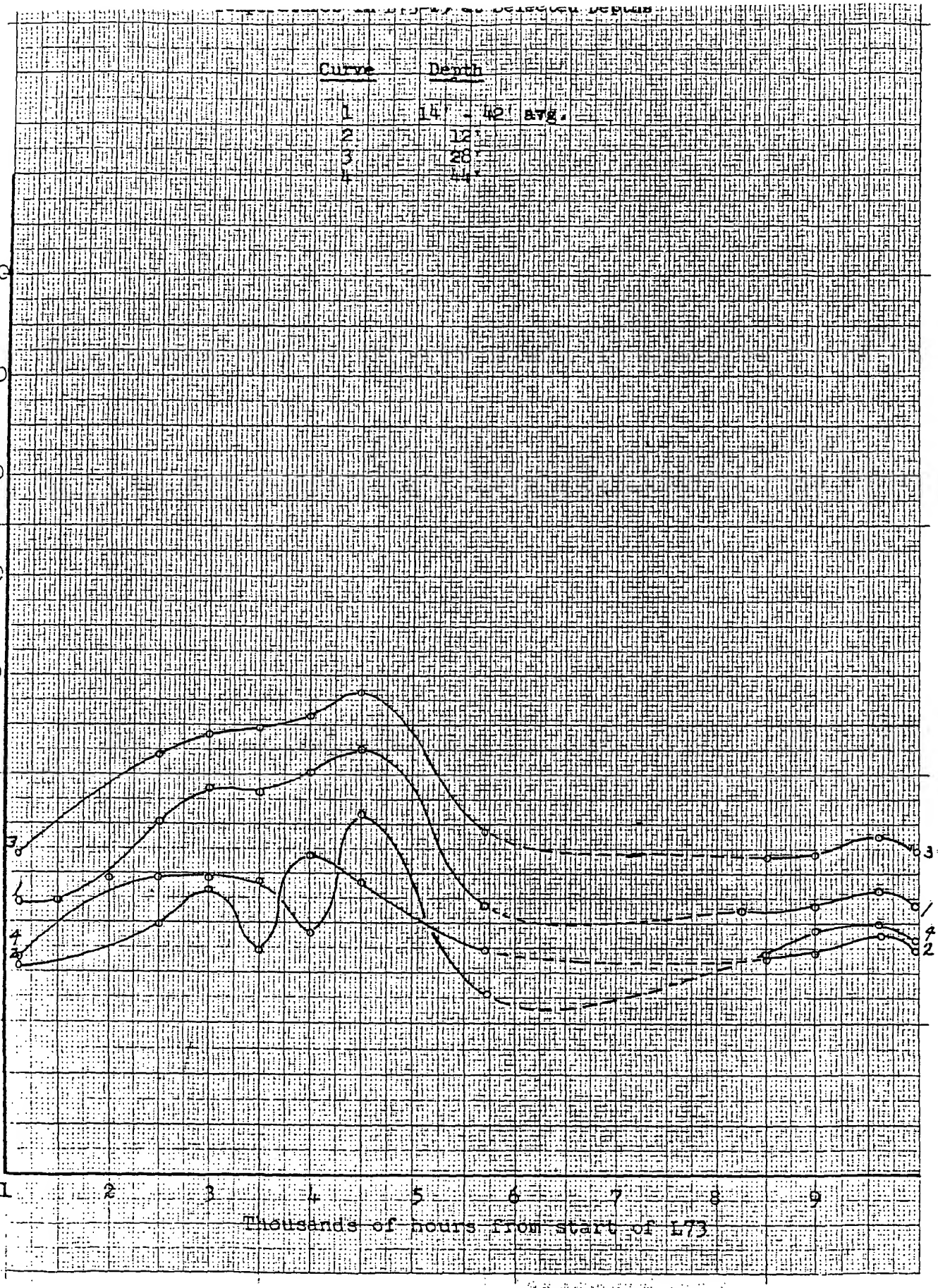

Temperatures in Lipari at selected times
Curve
Time (hours)
1
1124
2
2516
3
4484
4
9989
10
20
30
40
Depth in feet
200
300
400
500
600
700
800
900
Temperature in Fahrenheit

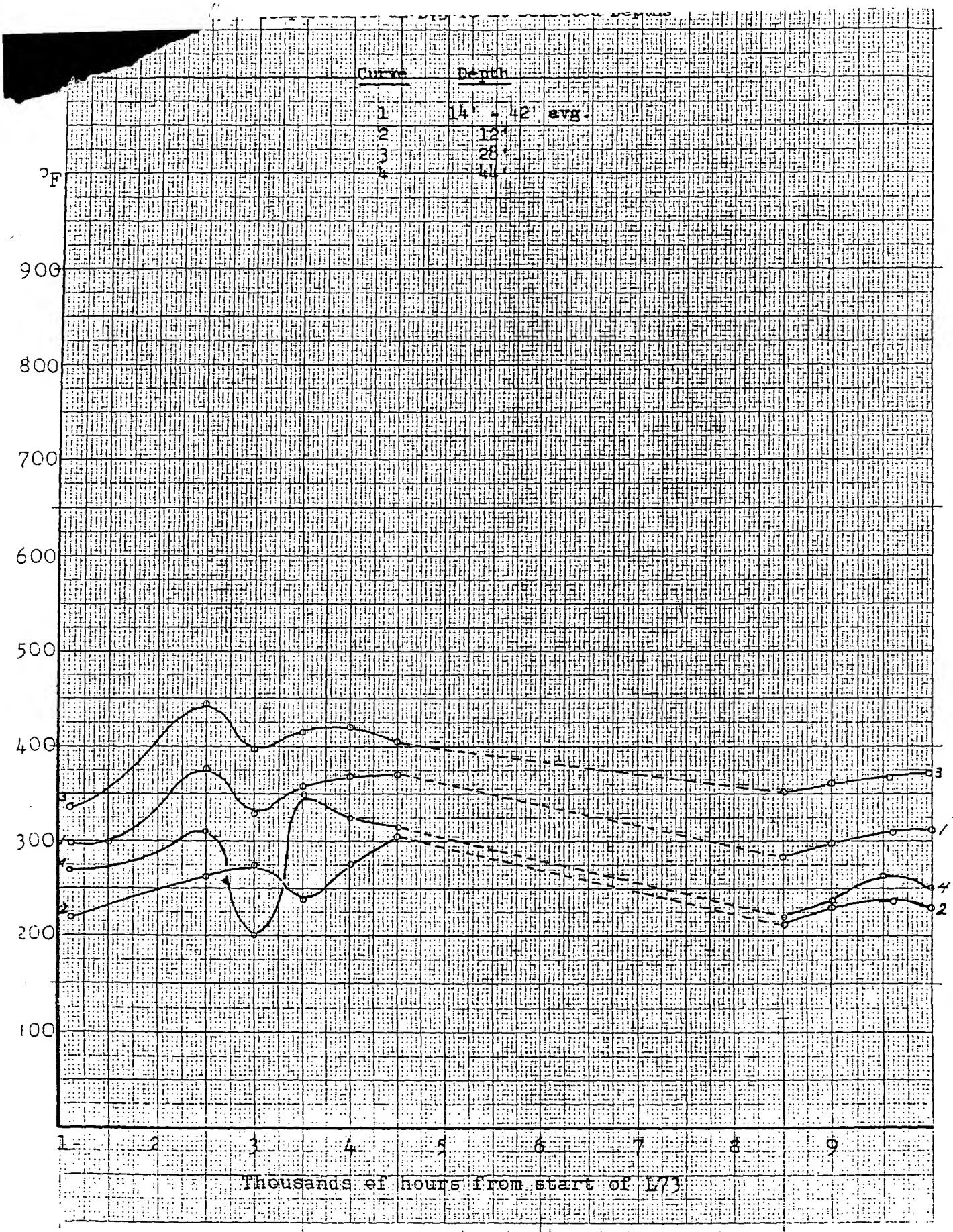



Temperatures in L73-T2 at Selected Depths
Curve
Depth
1
14' - 42' avg.
2
12'
3
28'
4
42'
°F
900
800
700
600
500
400
300
200
100
1
2
3
4
5
6
7
8
9
Thousands of hours from start of L73


Temperatures in L73-T3 at Selected Depths
Curve Depth
1 14' - 42 avg.
2 12'
3 28'
4 44'
°F
900
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
Thousands of hours from start of L73


Temperatures in L73-T4 at Selected Depths
Curve
Depth
1
14' - 42' avg.
2
12'
3
28'
4
44'
°F
900
800
700
600
500
400
300
200
00
1
2
3
4
5
6
7
8
9
Thousands of hours from start of L73


Curve Depth
1 14' - 42' avg.
2 12'
3 28'
4 44'
900
800
700
600
500
400
300
200
100
00
1
2
3
4
5
6
7
8
9
Thousands of hours from start of L73


Curve Depth
1 14' - 42' avg.
2 12'
3 28'
4 44'
°F
900
800
700
600
500
400
300
200
100
1
2
3
4
5
6
7
8
9
Thousands of hours from start of L73